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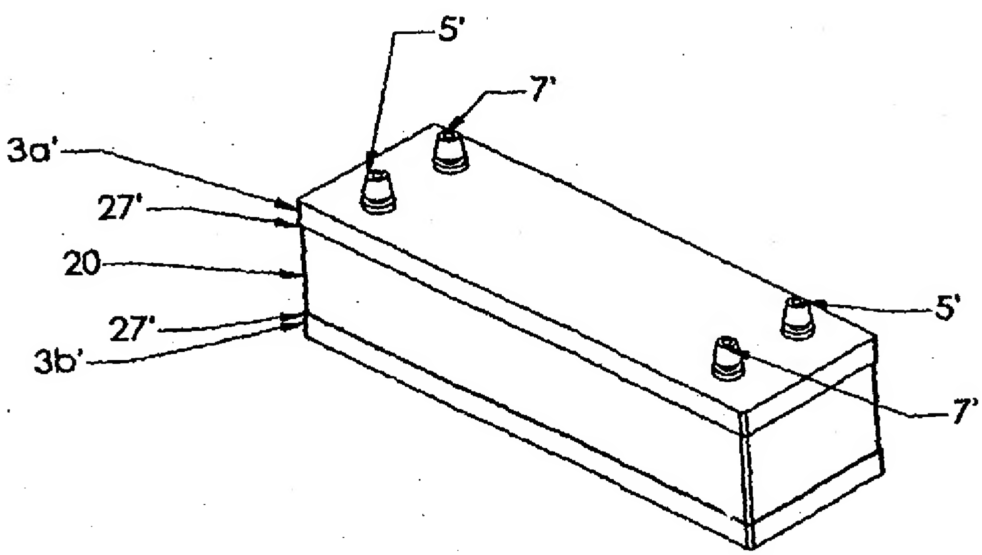
(54) Title: CROSS-FLOW FILTRATION CASSETTES AND METHODS FOR FABRICATION OF SAME



(57) Abstract: This invention relates generally to filtration cassettes (10), and, more particularly to methods of fabricating cross-flow filtration cassettes. Cassettes of the invention are characterized, in part, by an internal porting (e.g., manifolding) feature (5 and 7) which eliminates the need for a separate step to seal individual components prior to assembly of the filtration cassette. Filtration cassettes of the present invention can be manufactured from conventional membrane (13) and flow screen (9) components and can utilize both injection molding and vacuum assisted resin transfer molding fabrication processes.

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CROSS-FLOW FILTRATION CASSETTES AND METHODS FOR FABRICATION OF SAME

This application claims the benefit of U.S. Provisional Patent Application 60/365,456, filed March 19, 2002, which application is incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention.

This invention relates generally to filtration cassettes, and, more particularly to methods of fabricating cross-flow filtration cassettes. Cassettes of the invention are characterized, in part, by an internal porting (e.g., manifolding) feature which eliminates the need for a separate step to seal individual components prior to assembly of the filtration cassette. Filtration cassettes of the present invention can be manufactured from conventional membrane and flow screen components and can utilize both injection molding and vacuum assisted resin transfer molding fabrication processes.

2. Background.

Filtration cassettes are used in a variety of biotechnology and food processing applications. These cassettes typically comprise a stacked assembly of porous membrane components and filtrate and retentate flow screen components. During cross-flow filtration, a suspension is continually pumped into the retentate ports and through the cassette. Product that passes through the membrane is collected and passed out, e.g., drained, through the filtrate ports.

Filtration cassettes have conventionally been made using a multi-step process (see, e.g., US Patent No. 4,715,955). Generally, unused manifold ports on each of the individual flow screens (e.g., filtrate and retentate) are sealed. For example, in the case of the filtrate flow screen, ports utilized for the distribution of retentate on

other layers must be sealed about their perimeter to prevent mixing. This step can also be accomplished while binding one or more flow screens to the filtration membrane layer in the production of a subassembly. By either mode, a fixture is required to hold the flow screen in place and introduce resin and vacuum appropriately.

Next, component membranes or subassemblies and flow screens which have been sealed as described above are layered within a mold or other fixture according to the design requirements for the finished filtration cassette. Once the components have been assembled within the mold, a resin is introduced about the periphery. Using conventional vacuum transfer molding techniques, the resin is drawn into the edges of the cassette assembly. Once hardened, the resin provides structural support and edge sealing around the cassette.

The resulting fabricated filtration cassette may then be utilized for its intended application by fixing it between end plates, which provide appropriate manifolding and a means of compression. The compression allows sealing between the filtration cassette and the manifold within the endplate, as well as sealing between the components of the cassette itself. This conventional fabrication process is time intensive, costly and cannot be easily automated. Further, the compression required for sealing of the fabricated cassette, both between components and between the cassette and the manifolds within the end plate, results in reduced seal reliability.

Given these and other deficiencies observed in the art, it would be highly desirable to develop improved filtration cassettes and methods for their fabrication. It would be particularly desirable to improve seal reliability within the fabricated filtration cassette. Still further, it would be equally desirable to reduce time and manufacturing costs associated with filtration cassette fabrication.

SUMMARY OF THE INVENTION

The present invention provides improved cross-flow filtration cassettes and methods for their fabrication. Cassettes of the invention are characterized, in part, by an

internal manifold design. The novel features of the present invention permit internal port sealing of the flow screen components contemporaneously with encapsulation of the filtration cassette. In that way, the present invention eliminates the need for separate port sealing of individual components prior to assembly of the filtration cassette.

Preferred filtration cassettes of the invention generally comprise one or more filter membranes, each having at least one port for filtrate flow and at least one port for retentate flow; one or more filtrate flow screens, each having at least one port for filtrate flow and at least one port for retentate flow and further having one or more channels in proximity to and at least partially surrounding the port for retentate flow; and one or more retentate flow screens, each having at least one port for filtrate flow and at least one port for retentate flow and further having one or more channels in proximity to and at least partially surrounding the port for filtrate flow. In accordance with the present invention, sealant is introduced about the periphery of the one or more filter membranes, filtrate flow screens, and retentate flow screens to encapsulate the periphery thereof. The sealant also seals the channels of the one or more filtrate flow screens and retentate flow screens. The sealed channels selectively block the one or more ports in proximity thereto. In that way, certain ports selectively remain closed or open and undesired flow is reduced or eliminated.

Through the number, shape, and placement of sealant holes (optional) and channels cut within the flow screen components, sealing resin introduced during edge encapsulation is drawn into the individual flow screen components within the assembly to seal certain ports while leaving others unsealed. Thus, the sealing of unused manifold openings / ports within each particular flow screen occurs in combination for all components of the filtration cassette assembly and in combination with the edge encapsulation of the assembled filtration cassette components. Filtration cassettes of the present invention can be manufactured from conventional membrane and flow screen components and can utilize both injection molding and vacuum assisted resin transfer molding fabrication processes.

The present invention allows for the fabrication of filtration stacks with a minimum of labor, thereby dramatically reducing their cost and allowing for process automation. Additionally, in accordance with the present invention, the ports are sealed by adhesion of the sealant to the cassette components, not by compression of the endplates or other compression means. This feature provides notable advantages as compared to conventional cassettes and methods. For instance, sealing by adhesion in accordance with the invention, reduces the compression required on the final stack, improves the reliability of the seals and allows for the use of a wider variety of sealants/resins. Further, end plates may be molded into the filtration cassette thereby producing an entire stack (e.g., filtration cassette and end plates) in one step.

Other aspects of the invention and related methods are discussed *infra*.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1A is a side view of a prior art filtration cassette;

FIGURES 1B-1D are top views of the flow screen and membrane components of a prior art filtration cassette;

FIGURE 1E is an exploded view of the flow screen and membrane components of a prior art filtration cassette; and

FIGURE 1F is a photographic image of a prior art filtration cassette.

FIGURES 2A-2C are top views of the flow screen and membrane components for a filtration cassette of the present invention having both sealant holes and channels; and

FIGURES 2D-2F are top views of the flow screen and membrane components for a filtration cassette of the present invention having channels only.

FIGURES 3A-3C are top views of the flow screen and membrane components of one embodiment of the present invention showing exemplary sealant hole and channel configurations.

FIGURES 4A-4B are top views of the flow screens shown in FIGURES 2B-2C after sealing/encapsulation has occurred; and

FIGURES 4C-4D are top views of the flow screens shown in FIGURES 2E-2F after sealing/encapsulation has occurred.

FIGURE 5 is a top view of a filtration cassette of the present invention having bonded endplates.

FIGURE 6 is a photographic image of a filtration cassette made via the present invention.

DETAILED DESCRIPTION OF THE INVENTION

As discussed above, the present invention provides improved filtration cassettes and methods of fabricating cross-flow filtration cassettes. Cassettes and methods of the invention feature an internal manifold design. In accordance with the present invention, internal port sealing of the flow screen components occurs within the encapsulation step and without the need for separate port sealing of individual components prior to assembly of the filtration cassette.

Cassettes and methods of the invention and their distinctions from the prior art, will be further understood with reference to the drawings within. Referring to **FIG. 1A**, a filtration cassette **10**, representative of a typical embodiment of the prior art, is shown fixed between a first endplate **3a** on the top of cassette **10** and a second endplate **3b** on the bottom of cassette **10** through a compression means **27**. Manifolding for filtrate **5** and retentate flow **7** also is depicted. Referring also to **FIGS. 1B-1D**, the filtration cassette **10** is comprised of a stack of filtrate flow screens **9**, retentate flow

screens **11**, and filter membranes **13**, with the final stacking configuration of the components dependent upon the capacity requirements of the completed filtration cassette.

Referring in particular to **FIGS. 1B-1D**, a prior art filtrate flow screen **9**, retentate flow screen **11**, and filter membrane **13** are shown. Each of the flow screens **9** and **11** and membrane **13** components contain ports to allow for filtrate and retentate flow through the cassette. Typically, two sets of ports are cut for the manifolding of each of the filtrate **5** and retentate **7** flows (e.g., at least one inlet and at least one outlet for each flow). On the filtrate **9** and retentate **11** flow screen, sealed ports **15** are utilized to prevent undesirable flow, e.g., into the wrong flow screens. In the prior art, all ports are cut into individual flow screens and one or more such flow screens are stacked within a mold. Ports which are to remain unsealed are closed off and sealant is introduced into the mold. A vacuum is applied to pull the sealant into the porous flow screens and seal the open ports on such flow screens.

As shown in **FIG. 1E**, individual filter membrane **13** and filtrate and retentate flow screens **9** and **11** of the prior art having appropriate sealed ports **15** and unsealed ports **21** are assembled into the required filtration cassette design. The assembly is placed in a mold and sealant is introduced about the periphery of the assembly. A vacuum is pulled which infuses open peripheral edges of the components with the sealant to encapsulate the entire periphery of the filtration cassette. **FIG. 1F** shows a photographic image of the assembled filtration cassette of the prior art; additional reference to the encapsulated periphery is indicated by reference numeral **4**.

Unlike prior art methods in which sealing of the unused ports occurs prior to cassette assembly, the present invention provides a method for sealing the unused ports of each component simultaneously and in conjunction with the edge encapsulation of the filtration cassette, either using injection molding or vacuum resin transfer molding techniques.

Preferred methods for fabricating a filtration cassette of the invention generally comprise providing one or more filter membranes, each having at least one port for filtrate flow and at least one port for retentate flow; providing one or more filtrate flow screens, each having at least one port for filtrate flow and at least one port for retentate flow and further having one or more channels in proximity to and at least partially surrounding the port for retentate flow; and providing one or more retentate flow screens, each having at least one port for filtrate flow and at least one port for retentate flow and further having one or more channels in proximity to and at least partially surrounding the port for filtrate flow. The components of the filtration cassette (filter membrane, filtrate flow screen and retentate flow screen) are stacked in a number and manner of assembly which reflects the desired output/cassette design. Encapsulation of the components of the filtration cassette is then achieved by introducing a sealant about the periphery of the filter membrane, the filtrate flow screen, and the retentate flow screen. The sealant contemporaneously seals the respective channels of these components.

In preferred embodiments of the present invention, each of the filter membranes, filtrate flow screens and retentate flow screens will comprise at least two ports for filtrate flow and at least two ports for retentate flow. As will be appreciated by the skilled artisan, one of the two ports provides access for "in-flow", while the other accommodates "out-flow".

Referring again to the drawings, filtrate **9'** and retentate **11'** flow screens of the present invention are preferably cut from a woven or mesh material, including but not limited to polyester, polypropylene, other plastics, and the like. Indeed, any form which will allow fluid flow to travel parallel and through the sceen will be generally suitable for use in accordance with the invention.

As will be appreciated by the skilled artisan, filter membranes **13'** of the present invention are cut from a variety of membrane materials known in the art. By way of illustration, the example below utilizes a porous backed polysulfone membrane.

In that way, a non-woven material may be utilized as a backing which provides strength and serves as a carrier. Preferred membrane filters include ultrafiltration, microporous, nanofiltration or reverse osmosis filters formed from polyvinylidene fluoride (PVDF), polysulfone, polyethersulfone, regenerated cellulose, polyamide, polypropylene, polyethylene, polytetrafluoroethylene, cellulose acetate, polyacrylonitrile, vinyl copolymer, polyacrylonitrile, vinyl copolymer, polyacrylonitrile, vinyl copolymer, polycarbonate, PFA, blends thereof or the like. In a particularly preferred embodiment of the invention, filter membranes **13'** are cut from porous polymer material, such as polysulfone membranes made via casting and quenching techniques (i.e., phase inversion), track etched polycarbonates, or other similar materials.

Preferably, all of the components are cut to roughly the same shape and perimeter. Ports are cut in the filter membrane **13'** and flow screens **9'** and **11'** to provide manifolding for filtrate flow **5'** and retentate flow **7'** through the resulting cassette **20** (shown in **FIG. 5**). In the present invention, channels **19** also are cut in each of the filtrate flow screens **9'** and retentate flow screens **11'** through which a sealant can travel or otherwise be guided from the edge of the flow screens to close off unused ports, contemporaneously with the encapsulation of the edge of the filtration cassette **20**. Using the shape and placement of the channels in each of the components, sealant flow into the component is controlled. Specifically, the sealant flows faster in the open areas defined by the channels in each component than through the remainder of the component. Channels are not cut for ports that are not to be sealed on the individual component.

Depending upon the length of the channels and flow screen geometry (e.g., spacing and diameter of the mesh weave), sealant flow from the edge may not be adequate to completely seal off the port. In such instances, one or more sealant holes **17** are cut into the components and are utilized to enhance sealing of the channels **19**. Sealant holes **17** draw or otherwise permit entry of additional sealant into the channels **19**.

Referring now to **FIGS. 2A-C**, a basic channel **19** pattern for each component within a filtration cassette **20** of the present invention is shown, in which a series of sealant holes **17** are added to feed sealant to the channels **19**. The filter membrane **13'** is cut with two sets of ports and sealant holes **17** by punching with a steal rule die. The filtrate **9'** and retentate **11'** flow screens are cut with the same number and size ports as the filter membrane **13'** with both sealant holes **17** and channels **19** added. Channels **19** are cut in the flow screens **9'** and **11'** to align with the sealant holes **17** of the other components of the cassette. Two separate patterns of channels **19** are needed; one for each of the flow screens **9'** and **11'** to correspond to the distribution of filtrate **5'** and retentate **7'**.

FIGS. 2D-F show an alternate basic pattern of channels **19** for each component within filtration cassette **20** of the present invention without the addition of the sealant holes **17** described above. In that embodiment, channels **19** are cut from the edge of each individual component **9'**, **11'** and **13'**, thereby allowing resin to flow from the edge into channels **19**.

FIGS. 3A-C show an embodiment of sealant holes **17** and channels **19** on filter membrane **13'**, filtrate flow screen **9'** and retentate flow screen **11'** designed for filtration cassette **20** to match with existing end-plate fixtures. As shown, channels **19** were added to the membrane **13'** portion to improve sealant flow.

Once suitable sealant holes **17** and/or channels **19** are cut in each of the components **9'**, **11'**, and **13'** as described above, the components are assembled according to the desired filtration cassette design and output requirements. A very basic design would include a first filtrate flow screen **9'**, a first filter membrane **13'**, a retentate flow screen **11'**, a second filter membrane **13'** and a second filtrate flow screen **9'**. However, those skilled in the art will recognize that filtration cassettes can have any desired number of flow screens and filter membrane components assembled together.

Regardless of the particular design, the components are assembled such that the ports of each component in the assembly are aligned with the ports of the other components. The assembly is then placed within a mold or cavity and held in place within the mold by a top plate with an appropriate means of compression, such as a simple clamp or bolt pattern. If sealant holes **17** are utilized, then the top plate will also contain holes through which the sealant can be introduced into the assembly.

To encapsulate the filtration cassette assembly described above using vacuum resin transfer molding techniques, a sealant is introduced about the periphery and into any sealant holes of all assembled components. A vacuum is pulled through each of the ports within the assembly. The pressure differential pulls sealant into the edges of the assembly thereby encapsulating all the edges of the components in the assembly together and forming the assembly into a filtration cassette. In addition, the same pressure differential pulls the sealant from the edge into the channels **19** cut in each of the flow screen components. If sealant holes are present, the pressure differential pulls the sealant through the sealant holes into the channels. The sealant is drawn more quickly into the open channels than into the flow screen material and seals each port around which the channels are cut. Sealant still flows into the flow screen material, but at a rate too slow to close off the associated port. The edge encapsulation and port sealing is complete when the sealant flows through the channels to meet and seal off the appropriate ports.

Throughout the cassette assembly, each flow screen is appropriately sealed such that only the manifold ports of interest remain open on each individual layer. The remaining ports are enclosed by the channels that are now sealed. The edges of the assembly also are encapsulated by sealant. The pressure differential and time required to accomplish the sealing process is a function of the materials used for the flow screen, membrane components and the sealant, including but not limited to mesh size of the screen, as well as the viscosity and flow characteristics of the sealant.

To encapsulate a filtration cassette of the present invention using injection molding techniques, sealant is injected around the periphery of the assembly and into any sealant holes using a driving pressure means. In the preferred embodiment, a thermoplastic resin is utilized as the sealant and is injected into the injection holes and around the edges of the assembly and allowed to cool and harden prior to removal of the filtration cassette from the mold. A mold capable of accommodating the associated temperature and pressure is utilized.

The sealant used for encapsulation and port sealing is selected such that it has the required chemical and mechanical properties for the conditions found in an operating filtration system, including but not limited to low leachables, temperature stability, and solvent compatibility. Suitable sealants include both thermoplastics and thermoset elastomers. Preferred thermoplastics include thermoplastic olefin elastomers, thermoplastic polyurethane, plastomer, polypropylene, polyethylene, polytetrafluoroethylene, fluorinated polypropylene and polystyrene. Preferred thermoset elastomers include epoxy resins, urethanes, silicones, fluorosilicones, and vinyl esters.

FIGS. 4A-4B and **FIGS. 4C-4D** show the encapsulated edge **23** and sealed channels **25** resulting from the embodiments shown in **FIGS. 2A-2C** and **FIGS. 2D-2F**, respectively. For example, in the case of the retentate flow screen **11'** shown in **FIGS. 4A-4B**, the retentate ports **7'** remain open after the encapsulation, while the filtrate ports **5'** have been closed on this particular component/layer. Indeed, the novel design of the present invention selectively blocks those ports which are intended to be closed, by sealing of the respective channels in proximity to those ports.

Referring now to **FIG. 5**, end plates **3a'** and **3b'** may be bonded directly to the filtration cassette **20** during the encapsulation step, thereby producing an entire stack (e.g., filtration cassette and end plates). Rather than using a removable means of compression in the encapsulation step, the top and bottom plates of the mold can be replaced with end plates **3a'** and **3b'**. Upon encapsulation, end plates **3a'** and **3b'** are

incorporated into the filtration cassette **20**. If sealant holes **17** are utilized in distributing sealant into the interior of the cassette **20**, sealant holes **17** are added to at least one of the end plates.

Several benefits result from the bonding of the end plates directly to the filtration cassette. For instance, removing the need to compress the filtration cassette between end plates significantly improves the reliability of the filter. Also, the incorporated end plates can include fittings to further simplify the filter. In addition, the bonded filtration cassette and end plate assembly could be made disposable, thereby eliminating the need for fixed hardware end plates and their cleaning and sterilization.

FIG. 6 is a photographic image of the filtration cassette of the present invention showing sealing and edge encapsulation. Channels **19**, sealant holes **17**, and respective ports for filtrate flow **5'** and retentate flow **7'** are shown, as is the encapsulated edge **23** about the periphery of the cassette.

The preferred filtration cassette of the present invention is further illustrated by means of the following illustrative embodiment, which is given for purpose of illustration only and is not meant to limit the invention to the particular components and amounts disclosed therein.

Example 1

Using the channel and sealant hole patterns depicted in **FIGS. 3A-C**, filtrate and retentate flow screens were cut from polyester screen stock. Microporous membranes of backed polysulfone were made through conventional processes know in the art. Channels were cut in the filter membranes in accordance with the pattern shown in **FIGS. 3A-C**. Several each of the filtrate flow screens, retentate flow screens, and membranes were layered in a mold. The assembly was encapsulated with the silicone resin, CF 19-2186, (available commercially from NuSil Technology of

Carpinteria, California) by applying a vacuum of 10 inches Hg for approximately 20 seconds.

Table 1 shows results for water flux, pressure drop and 15kD blue dextran passage properties of the filtration cassettes made via the processes described above. For comparison, water flux, pressure drop and 15kD blue dextran passage properties of filtration cassettes fabricated through prior art methods are shown in Table 2.

The data shows comparable performance between our cassette and that of the prior art. While maintaining an optimum level of performance, the present invention provides several advantages over conventional cassettes and processes for their fabrication. Notable advantages include improved seal reliability within the fabricated cassette, reduced time and manufacturing costs and suitability for automation.

Table 1

Pressure			Pressure Drop	Avg. Pressure	Water Flux	Flux Pressure	K15 flux	Flux/ Pressure	K15 passage
Feed	Retenate	Filtrate	(Pfeed-Pret)	(Pfeed+Pret)/ 2-Pfil					%
Pfeed (psi)	Pret (psi)	Pfil (psi)	(psi)	(psi)	ml/min/cm^2		ml/min/cm^2		
16	4	0	12	10	0.126	0.0126			
21	10	0	11	15.5	0.182	0.0117			
24	13	0	11	18.5	0.229	0.0124			
29	18	0	11	23.5	0.288	0.0123			
15	3	0	12	9			0.106	0.0118	47
21	10	0	11	15.5			0.185	0.0106	49
25	14	0	11	19.5			0.191	0.0098	52

Protonex Cassette

Membrane area: 0.5 ft^2 466.7 cm2

Lot#: 11602

TABLE 2

Pressure			Pressure Drop	Avg. Pressure	Water Flux	Flux Pressure	K15 flux	Flux/ Pressure	K15 passage
Feed	Retenate	Filtrate	(Pfeed-Pret)	(Pfeed+Pret)/ 2-Pfil					%
Pfeed (psi)	Pret (psi)	Pfil (psi)	(psi)	(psi)	ml/min/cm^2		ml/min/cm^2		
15	4	0	11	9.5	0.141	0.0148			
20	10	0	10	15	0.206	0.0137			
26	15	0	11	20.5	0.288	0.0140			
15	4	0	11	9.5			0.11	0.0116	45
20	10	0	10	15			0.169	0.0113	46
26	14	0	12	20			0.199	0.0100	47

Traditional Cassette

Membrane area: 0.5 ft^2 466.7 cm^2

Lot#: ML011602IL013

CLAIMS

Subject matter claimed:

1. A filtration cassette comprising:

one or more filter membranes, each having at least one port for filtrate flow and at least one port for retentate flow;

one or more filtrate flow screens, each having at least one port for filtrate flow and at least one port for retentate flow and further having one or more channels in proximity to and at least partially surrounding the port for retentate flow; and

one or more retentate flow screens, each having at least one port for filtrate flow and at least one port for retentate flow and further having one or more channels in proximity to and at least partially surrounding the port for filtrate flow;

wherein the one or more filter membranes, filtrate flow screens and retentate flow screens are assembled and encapsulated about the periphery thereof by a sealant; and

wherein the sealant contemporaneously seals the respective channels of the one or more filtrate flow screens and retentate flow screens to selectively block one or more ports in proximity thereto.

2. The filtration cassette of claim 1, wherein the channels are cut from the respective edges of the one or more filtrate flow screens and retentate flow screens.

3. The filtration cassette of claim 1, wherein each of the one or more filter membranes, filtrate flow screens and retentate flow screens further comprises one or more sealant holes to enhance sealing of the respective channels.

4. The filtration cassette of claim 3, wherein the sealant holes of the one or more filter membranes, filtrate flow screens and retentate flow screens are in respective alignment with each other.

5. The filtration cassette of any one of claims 1-4, wherein the ports of each of the filter membrane, filtrate flow screen and retentate flow screen components are in respective alignment with each other.

6. The filtration cassette of any one of claims 1-5, wherein the filter membrane is positioned, respectively, between the filtrate flow screen and the retentate flow screen.

7. The filtration cassette of any one of claims 1-6, further comprising a first and second end plate attached at either end thereof.

8. The filtration cassette of claim 7, wherein the first and second end plates are encapsulated into the cassette.

9. The filtration cassette of claim 1, wherein the filter membrane is selected from the group consisting of ultrafiltration, microporous, nanofiltration or reverse osmosis filters formed from polyvinylidene fluoride (PVDF), polysulfone, polyethersulfone, regenerated cellulose, polyamide, polypropylene, polyethylene, polytetrafluoroethylene, cellulose acetate, polyacrylonitrile, vinyl copolymer, polyacrylonitrile, vinyl copolymer, polyacrylonitrile, vinyl copolymer, polycarbonate, PFA, and blends thereof.

10. The filtration cassette of claim 1, wherein the filter membranes comprise a porous polymer material.

11. The filtration cassette of claim 10, wherein the porous polymer material comprises a polysulfone membrane.

12. The filtration cassette of claim 1, wherein the filtrate flow screens and retentate flow screens comprise a mesh material.

13. The filtration cassette of claim 12, wherein the mesh material comprises polyester or polypropylene.

14. The filtration cassette of claim 1, wherein the sealant is selected from the group consisting of thermoplastic materials and thermoset elastomers.

15. The filtration cassette of claim 14, wherein the thermoplastic material is selected from the group consisting of thermoplastic olefin elastomers, thermoplastic polyurethane, plastomer, polypropylene, polyethylene, polytetrafluoroethylene, fluourinated polypropylene and polystyrene.

16. The filtration cassette of claim 14, wherein the thermoset elastomers are selected from the group consisting of epoxy resins, urethanes, silicones, fluorosilicones, and vinyl esters.

17. The filtration cassette of claim 1, wherein each of the one or more filter membranes, filtrate flow screens and retentate flow screens are cut to roughly the same shape and perimeter.

18. A filtration stack assembly comprising one or more filtration cassettes and a first and second endplate attached at either end thereof, wherein each filtration cassette comprises:

one or more filter membranes, each having at least one port for filtrate flow and at least one port for retentate flow;

one or more filtrate flow screens, each having at least one port for filtrate flow and at least one port for retentate flow and further having one or more channels in proximity to and at least partially surrounding the port for retentate flow; and

one or more retentate flow screens, each having at least one port for filtrate flow and at least one port for retentate flow and further having one or more channels in proximity to and at least partially surrounding the port for filtrate flow;

wherein the one or more filter membranes, filtrate flow screens and retentate flow screens are assembled and encapsulated about the periphery thereof by a sealant; and

wherein the sealant contemporaneously seals the respective channels of the one or more filtrate flow screens and retentate flow screens to selectively block one or more

ports in proximity thereto.

19. A method for fabricating a filtration cassette comprising:

providing one or more filter membranes, each having at least one port for filtrate flow and at least one port for retentate flow;

providing one or more filtrate flow screens, each having at least one port for filtrate flow and at least one port for retentate flow and further having one or more channels in proximity to and at least partially surrounding the port for retentate flow; and

providing one or more retentate flow screens, each having at least one port for filtrate flow and at least one port for retentate flow and further having one or more channels in proximity to and at least partially surrounding the port for filtrate flow;

introducing a sealant about the periphery of the filter membrane, the filtrate flow screen, and the retentate flow screen to encapsulate the periphery thereof and to seal the respective channels.

20. The method of claim 19, wherein each of the filter membrane, filtrate flow screen and retentate flow screen components comprise sealant holes to enhance sealing of the respective channels.

21. The method of claim 19, further comprising assembling the one or more filter membranes, filtrate flow screens and retentate flow screens such that their respective ports are in alignment prior to introducing the sealant about the periphery thereof.

22. The method of claim 21, wherein a series of filter membranes, filtrate flow screens and retentate flow screens are assembled such that each respective membrane filter is positioned between a respective filtrate flow screen and respective retentate flow screen.

23. The method of any one of claims 19-22, further comprising attaching a first and second end plate at either end of the cassette thereof.

24. The method of claim 23, further comprising encapsulating the end plates into the cassette.

25. The method of any one of claims 19-24, further comprising encapsulating the filtration cassette about the periphery thereof and sealing the respective channels using injection molding or vacuum assisted resin transfer molding processes.

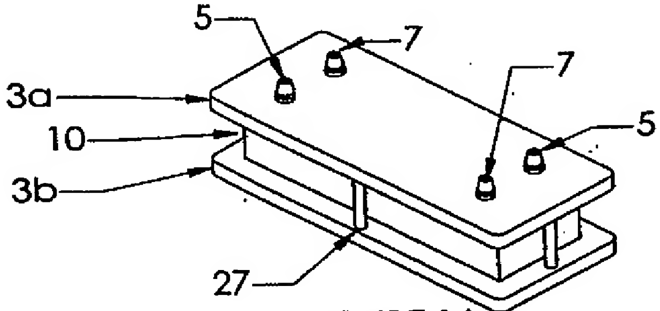

FIGURE 1A

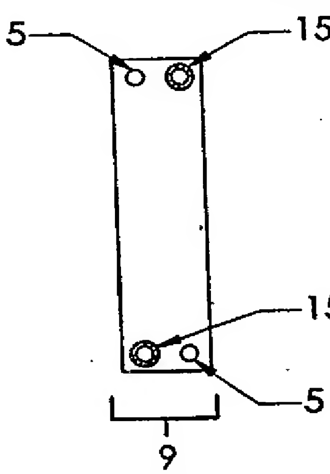

FIGURE 1B

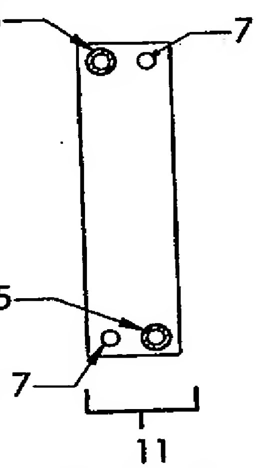

FIGURE 1C

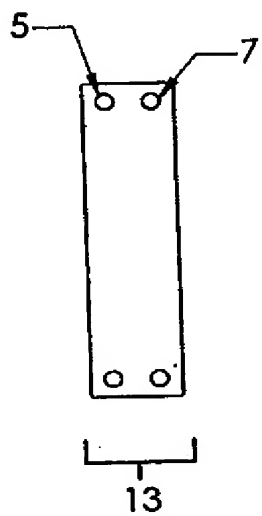

FIGURE 1D

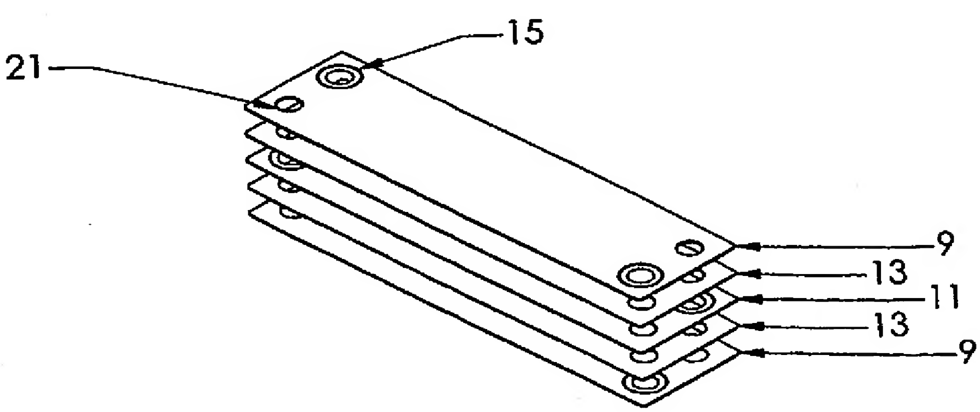

FIGURE 1E

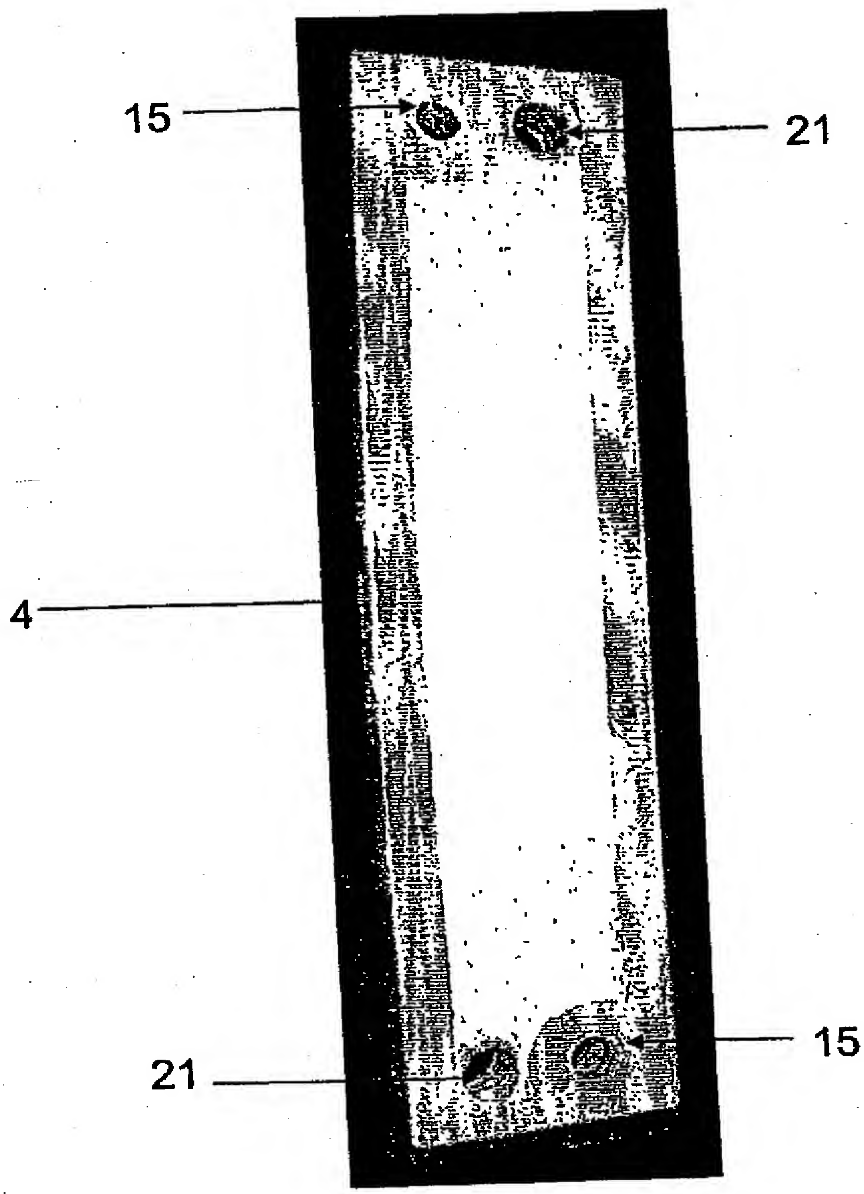

Figure 1F

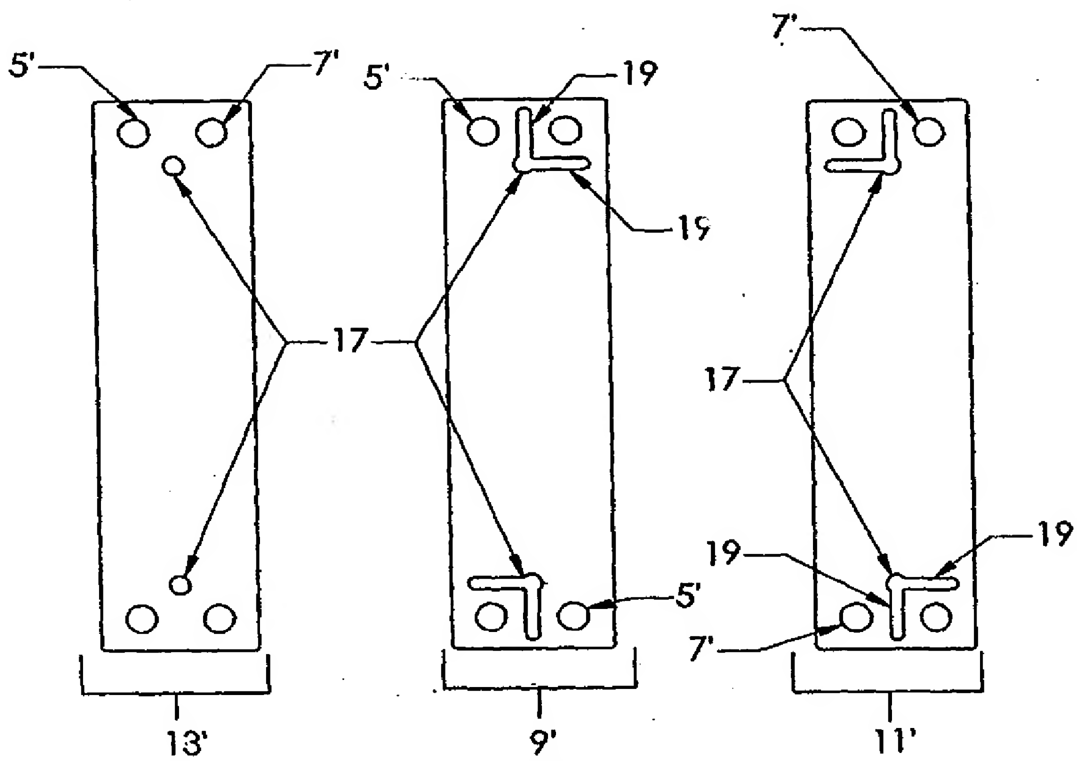

FIGURE 2A FIGURE 2B FIGURE 2C

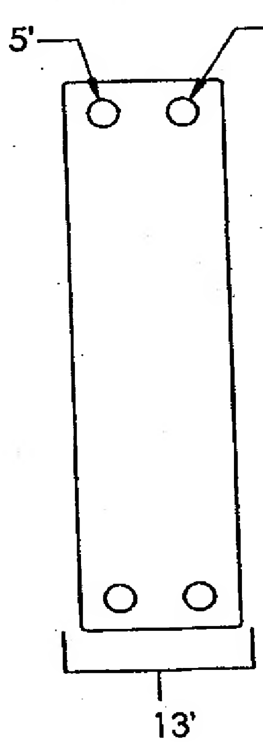

FIGURE 2D

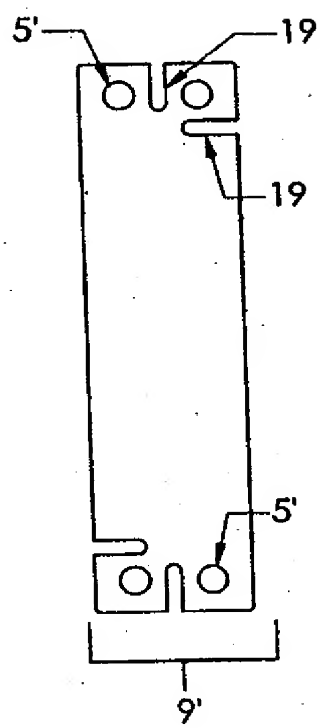

FIGURE 2E

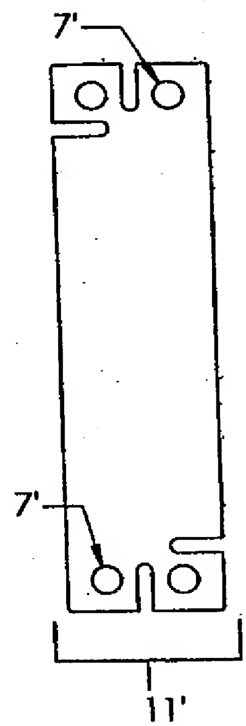

FIGURE 2F

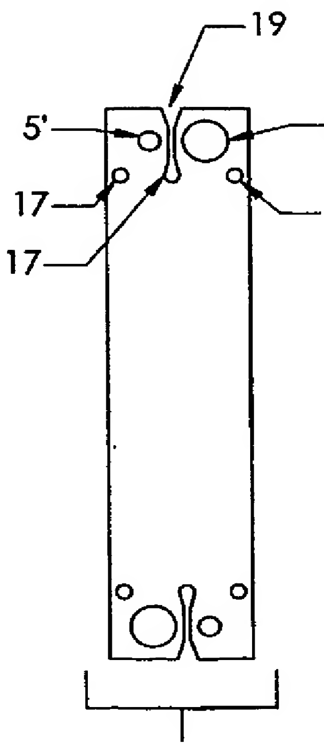

FIGURE 3A

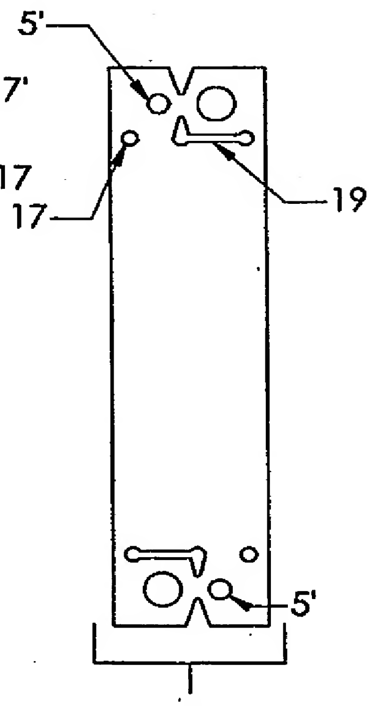

FIGURE 3B

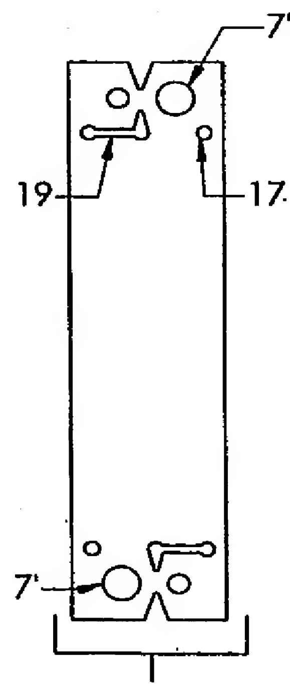

FIGURE 3C

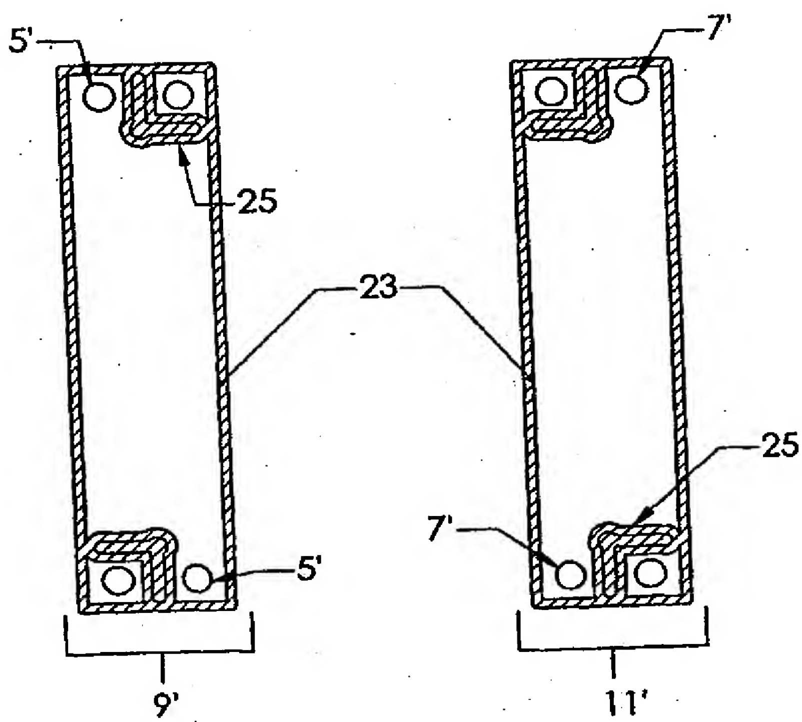

FIGURE 4A

FIGURE 4B

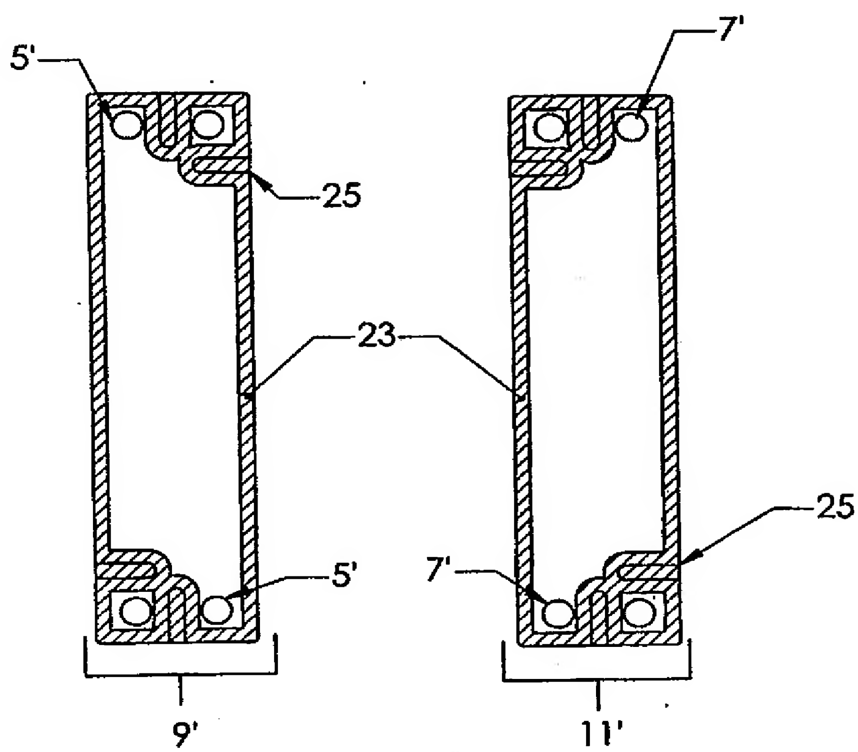

FIGURE 4C FIGURE 4D

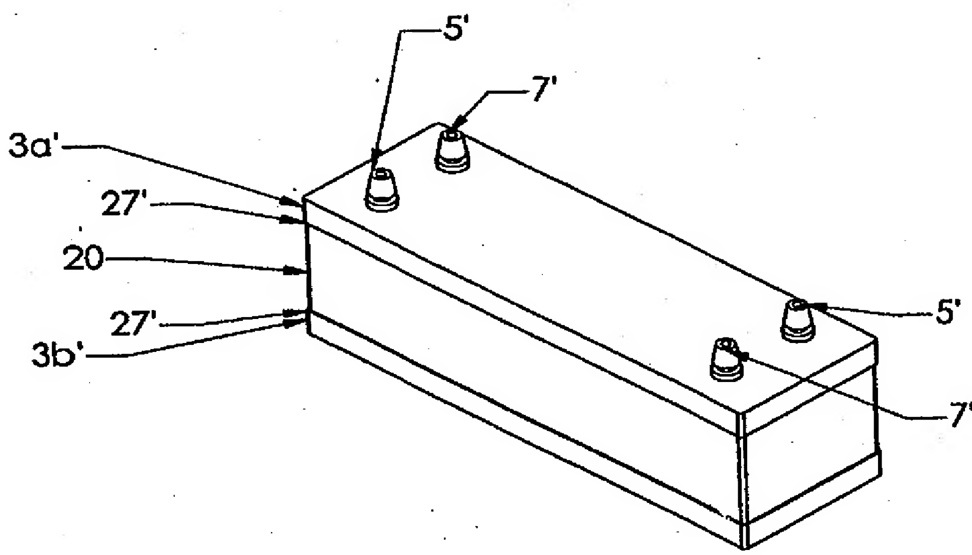

FIGURE 5

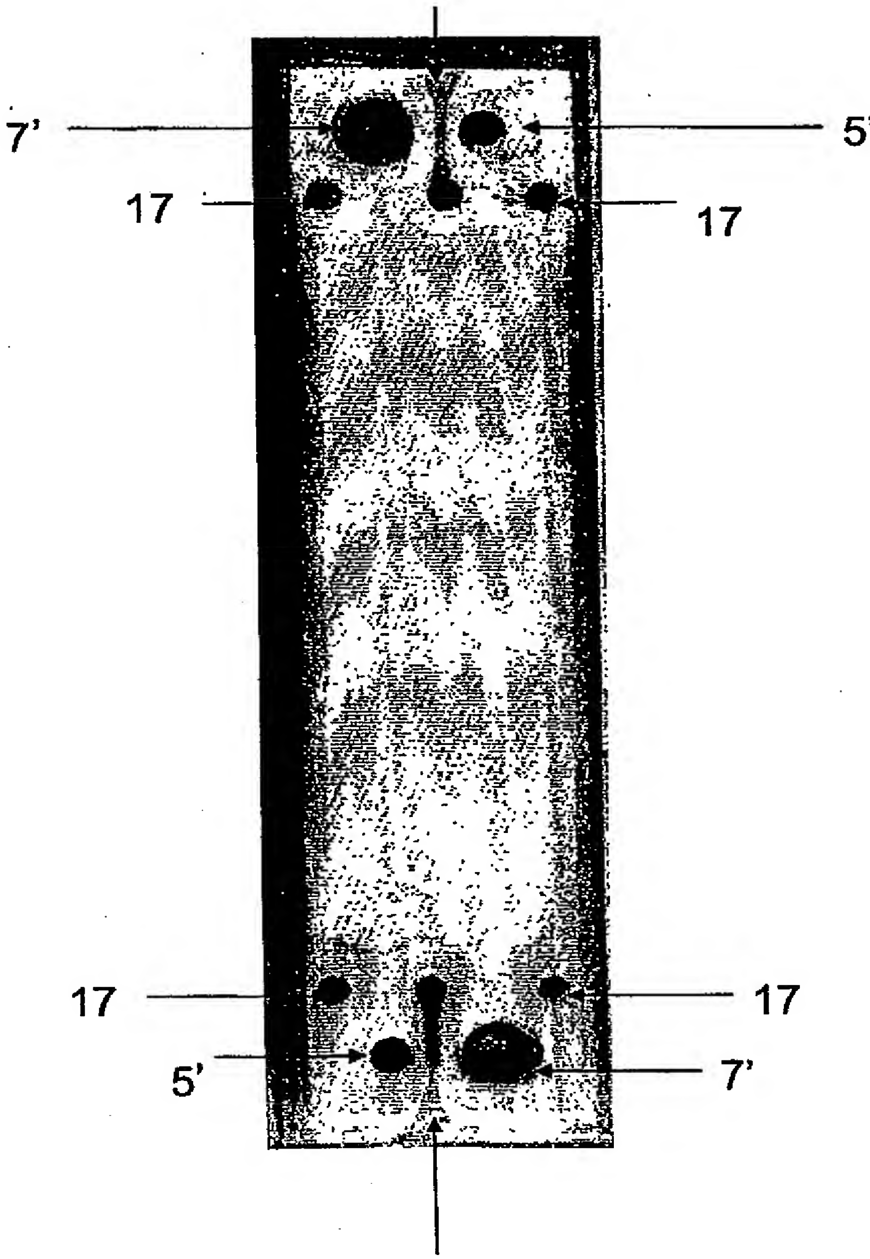

FIGURE 6

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US03/08446

A. CLASSIFICATION OF SUBJECT MATTER
IPC(7) : B01D 63/00
US CL : 210/321.75, 456, 231, 321.84, 321.6, 455
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 210/321.75, 456, 231, 321.84, 321.6, 455

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US 5,922,200 A (PEARL et al) 13 July 1999, column 1, lines 60-68, column 2, lines 1-47, and columns 3-6	1, 2, 5/1, 5/2, 6/1, 6/2, 7-17. --- 18-25
X	US 5,599,447 A (PEARL et al) 04 February 1997, entire disclosure.	1, 2, 5/1, 5/2, 6/1, 6/2, 7, 17, 18
Y	US 6,171,374 b1 A (BARTON et al) 09 January 2001, column 5, lines 4-68, and column 6, lines 1-49, column 14, lines 8-43.	16, 19
Y	US 5,342,517 A (KOPF) 30 August 1994, column 10, lines 18-37, column 12, lines 9-19, column 3, lines 40-66.	9, 13, 16
Y	US 4,735,718 A (PETERS) 05 April 1988, entire disclosure.	1, 2, 6-12

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent published on or after the international filing date

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search 04 June 2003 (04.06.2003)	Date of mailing of the international search report 19 JUN 2003
Name and mailing address of the ISA/US Mail Stop PCT, Attn: ISA/US Commissioner for Patents P.O. Box 1450 Alexandria, Virginia 22313-1450 Facsimile No. (703)305-3230	Authorized officer Ana Fortuna Telephone No. (703)308-0661

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